SEED GERMINATION AS AFFECTED BY FERTILIZER APPLICATIONS

by

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INTRODUCTION

There are several factors that affect the germination of good viable plant seeds. These factors may be placed in three broad groups: climatic, biotic, and edaphic. There are several important factors under each group heading. The most important climatic factors are precipitation, sunshine, and temperature. Under the biotic group, the most important factors are animals, including man, and other plants. The edaphic group includes mainly those factors reflecting biological and chemical properties of the soil.

Each of these factors (precipitation, sunshine, temperature, animals, biological and chemical properties of the soil) may affect the plants directly and are all interrelated in their effects. Seldom are all optimum at the same time.

Following germination, it is essential that one edaphic factor, the supply of available nutrients, be kept near the optimum in order to promote rapid seedling growth. An ample supply of available nutrients is a necessity and may be adjusted by the use of commercial fertilizers when all other factors are favorable.

In recent years, with the general decline in the fertility of our soils, the use of commercial fertilizers has increased. There is much information relative to the use of commercial fertilizers as plant nutrients. In recent years, with the advance of the science of plant nutrition, this knowledge has increased. With proper use and proper management of commercial fertilizers, yields frequently can be increased greatly.

With the increased use of commercial fertilizers and the increased knowledge of plant nutrition, there also is need for more knowledge as to the effect that the placement of the fertilizers has on seed germination which in turn affects the crop yield.

This investigation consisted of a study of the effects on germination of seeds of wheat, corn, and milo when fertilizer materials of various sorts were placed in direct contact with the seeds at various rates of application. An additional investigation included an evaluation of the significance of biuret toxicity upon the germination of wheat seed.

REVIEW OF LITERATURE

There has been limited work done in the past relative to the effect which placement of fertilizer has on the germination of seeds.

In some of the first work done with the placement of fertilizer in contact with seeds during the germination period, Ewert (2) reported that when wheat and superphosphate were placed together in dry soil, germination was affected. Germination was even more seriously affected when there was some free moisture present at the beginning of the process which was followed by soil drying. When germination took place fairly rapidly and the superphosphate was placed from one to three inches below the seeds, a stimulating effect in growth rate and an increase in the yield of both grain and straw was obtained.

Coe (1) compared broadcasting of fertilizer and placement of such in direct contact with the seed. When superphosphate (0-16-0) was applied at rates equivalent to 50 to 400 pounds per acre to oats and clover, the

direct contact fertilizer application method increased the yields and crops matured earlier than was true for either the use of no fertilizer or the method involving broadcast fertilizer application. For oats and clover, the direct contact fertilizer applications were superior to the broadcast fertilizer applications. When superphosphate (0-16-0) was applied at 50 to 400 pounds per acre rates of application to wheat, it was found that use of more than 200 pounds per acre application caused pronounced injury and depressed yields when applied in direct contact with seed as compared to the broadcast application method. The direct contact fertilizer application method was superior over the broadcast method for the application rates lower than 200 pounds per acre. When superphosphate (0-16-0) was applied to corn at 50 to 200 pounds per acre application rates, all broadcast application treatments produced higher yields than when the direct contact application method was used. When fertilizing corn it was thought by Coe that hill or banded placement of the fertilizer was superior to either broadcast or direct contact fertilizer application methods.

The germination of seeds is dependent upon the absorption of water when other conditions are favorable. Shive (9) said the soil solution offers resistance to the entrance of water into seeds by what is known as the "concentration of the solution." Work done by Shive by using varying concentrations of salt solutions, indicates that the retarding influence on the absorption of water caused by salt concentration is very plain. Germination may not necessarily be prevented by high salt concentration, but it may be retarded. This retardation is directly related to the reduction in the amount of water absorbed by the seed, which in turn is dependent upon the concentration of the soil solution.

More recently with the production of higher analyses fertilizers and new methods of producing them, there has been concern over another type of damage to the crop caused by the fertilizers. The production of pelleted urea has caused concern because of the damage to the crop when it is used.

Since about 1943 urea has been used as a foliage spray on citrus to supply nitrogen. Crystalline urea becomes very hard in a short time and is difficult to use. With new production methods, crystalline urea can be conditioned to form pellets which do not cake and which can be used easily. In producing the pellets the urea is heated. It is known that when urea is heated it is converted to biuret. The reaction is according to the following equation: $2\text{CO}\begin{matrix}\text{NH}_2\\\text{NH}_2\end{matrix} + \text{heat} = \text{NH}_2 - \text{CO} - \text{NH} - \text{CO} - \text{NH}_2 + \text{NH}_3$.

Urea used as a foliage spray may be conditioned urea. With the use of such conditioned urea as a foliage spray, leaf injury has been reported in citrus. This injury consisted of a yellowing of the tip of the leaves and is called "yellow-tip." Research conducted by Jones (5) indicated that extent of injury may vary from small amount to as much as ½ of the whole leaf. Jones also reported that leaves so affected did not recover after injury, but new leaves which developed after the plant was sprayed did not have the injury unless the plant was sprayed again. Biuret was first suspected as the cause of such injury.

In experiments conducted by Jones (5) it was found that "yellow-tip" resulted from solutions of pelletized urea, of biuret, and from biuret-crystalline urea combinations applied as a spray to the foliage or to the soil. No injury resulted from use of crystalline urea alone, whether applied as a foliar spray or in the form of an application to the soil.

The results indicated that biuret was the substance in commercial pelletized urea fertilizers which caused yellow-tip of citrus.

Jones, et al. (6) reported that urea containing more than 0.25 per cent biuret should not be used as a foliage spray because yellow-tip injury will result.

When urea solutions were applied to the soil, yellow-tip resulted from urea containing 2.3 per cent or more of biuret. Urea with more than 2.5 per cent biuret should not be used for soil applications to citrus. Yellow-tip which resulted from soil applications occurred as a result of the amount of biuret applied at that time, because there was no accumulation of biuret in the soil. It was changed to another form of nitrogen in about six weeks by soil organisms.

Starostka and Clark (12), experimenting with perennial ryegrass, corn, cotton, tomatoes, and oats in the greenhouse, concluded that biuret injured the ryegrass for a short time after application. After being in the soil for several weeks it was found to be a useful source of nitrogen for the crop. Urea-biuret mixtures containing up to 10 per cent by weight of biuret applied to the soil did not harm corn, tomatoes, cotton, or oats. The degree of nitrification of biuret was slow, but by the end of 15 weeks the nitrate content was the same as for use of either urea or ammonium sulfate.

Tests by Haas and Brusca (4) to determine what effect biuret had on citrus and avocado tree growth, demonstrated with citrus that 50 ppm of biuret in a nutrient solution caused slight chlorosis on new leaves. With 150 ppm of biuret, chlorosis appeared within a few days after the nutrient solution was applied. Leaf margins of half-grown leaves wilted

and became increasingly chlorotic. Mature leaves took somewhat longer to become chlorotic. On avocado plants, chlorosis of leaves was present on immature leaves after only a few days following use of nutrient solutions containing 50 to 200 ppm biuret. Mature leaves took somewhat longer to develop this condition but whenever biuret was present, chlorosis developed.

Funabiki, et al. (3), working in Japan, reported that high concentrations of biuret had no influence on the germination of wheat, naked barley, or paddy rice, but the growth immediately after germination suffered from the unfavorable effect of biuret. Wheat and naked barley suffered more than paddy rice. Symptoms of the injuries due to biuret appeared on the leaves as chlorosis with yellowish-white streaks. Root injury was indicated by a restraining effect. A water culture experiment showed that 20 to 30 ppm of biuret had a stimulating effect in the early stages of growth of wheat, naked barley, and paddy rice. Injury was more frequent during the winter than during the summer months. There was more injury from band placement than from mixing of the biuret with the soil.

Investigations involving use of urea sprays containing varying amounts of biuret on pineapple plants by Sanford, et al. (10), indicated that there was a positive correlation between toxicity symptoms and the amount of biuret, whether added to the urea or sprayed alone. This investigation suggested that "leaf-tip dieback" and yellowing of pineapple plants was caused by biuret in the urea and not by the urea itself. Urea containing 3 per cent or more of biuret caused dieback and chlorosis.

Ogata and Funabiki (7) stated that biuret is easily dissolved in water and not absorbed by soil particles, and is easily leached away from the surface soil by rain. Biuret may accumulate in the upper soil layer as a

result of evaporation and become injurious to plant growth. Biuret had no effect on the ammonification of urea in the field, but had a slight tendency to depress the activity of nitrifiers in the soil. This effect was not regarded as particularly important under field conditions, however.

Investigations conducted by the Spencer Chemical Company (11) evaluated the effect of pre-emergence applications of biuret to oats, radish, brome grass, snapbeans, tomatoes, cucumbers, alfalfa, sugar beets, flax, peas, corn, wheat, lettuce, carrots, and turnips. It was found that when biuret was applied at rates of 100 pounds per acre, it prevented the emergence of flax, peas, and turnips, and severely injured all other plants. When applied at 10 pounds per acre, it again prevented flax and peas from emerging and injured corn, wheat, lettuce, carrot, turnip, oats, radish, brome grass, snapbeans, tomatoes, and cucumbers. Biuret applied at rates equivalent to 10 pounds per acre did not affect alfalfa and had a stimulating effect on sugar beets. The injury was more severe on light textured soils than on heavier textured soils. The extent of injury varied with the kind of plant.

Work done by Okuda (8) involving the use of urea-biuret mixtures of from 1 to 10 per cent biuret indicated that growth and productivity of wheat was reduced with applications containing more than 5 per cent of biuret. Rice was not affected by biuret. A germination test using rice, wheat, barley, and radish in .0125 to .1 per cent biuret solutions indicated that germination was not affected but the growth of seedlings, particularly the roots, was inhibited in all tests.

METHODS AND PROCEDURE

The major problem studied was the effect of various fertilizers in contact with seeds upon the germination of such. In all studies the seeds were placed in direct contact with the applied fertilizer. Two trials were conducted in an atmosphere of 98 per cent relative humidity with known percentages of moisture in the germinating media. All other trials were conducted in an open greenhouse with the germinating media varying for some of the trials. The fertilizers varied as to brand, amount, and kind for the different trials. In some trials, the seeds were soaked in fertilizer solutions of varying concentrations for the fertilizer treatment.

The crop seeds used were Concho wheat, Westland milo, and W528 hybrid corn.

Three germinating media were used: (1) soil from the Agronomy Farm - a heavy silty clay loam soil; (2) soil from Ashland Agronomy Farm - a loamy sand soil; and (3) washed fine sand.

The fertilizers used were ammonium nitrate containing 33.5 per cent nitrogen, triple superphosphate containing 42 per cent available P_2O_5, muriate of potash containing 60 per cent K_2O, Urea I containing 45 per cent nitrogen and 8.87 per cent biuret, Urea II containing 45 per cent nitrogen and 5.04 per cent biuret, Urea III containing 45 per cent nitrogen and 2.15 per cent biuret, and two sources of crystalline urea each containing 45 per cent nitrogen and .08 per cent biuret. Rates of fertilizer applied always were based upon linear row length.

Greenhouse Studies

Trial I involved four replications of each treatment for each rate of fertilizer application. Random arrangement of greenhouse flats was employed. Soil from the Agronomy Farm was used as the germinating media and was placed in 14 x 22 x 3 inch flats, which were filled to within about ½ inch of the top so as to allow working space for the planting operation. No fertilizer, ammonium nitrate, triple superphosphate, and muriate of potash fertilizer treatments were used. The fertilizers were applied singly and in all possible combinations, 0-0-0, N-0-0, 0-P-0, 0-0-K, N-0-K, N-P-0, 0-P-K, and N-P-K. The treatments were applied at rates equivalent to 20 and 40 pounds of nitrogen per acre. Rates within the row were based upon a spacing as involved with 40-inch rows. Before the treatments were applied and the seeds were planted, each flat was thoroughly moistened throughout the entire depth of the soil in the flat. The fertilizer for each treatment was weighed upon an analytical balance prior to time of planting and was placed in the bottom of a furrow which was about one inch deep and 14 inches long. Each flat included a row of corn, wheat, and milo. Each corn row had 12 seeds, and each wheat and milo row had 50 seeds which were placed directly upon the fertilizer. After planting, the flats were watered daily to maintain the moisture supply. Sprouts above the surface of the soil were counted daily for 16 days after planting, at which time it was apparent that no more seedlings would emerge.

Trial II, using soil from Ashland Agronomy Farm, involved the same laboratory preparation and greenhouse preparation as mentioned above for Trial I.

In Trial III, which involved soil from the Agronomy Farm, the same fertilizers and the same fertilizer treatments as used in Trial I again were employed but the application rates were based upon a spacing as involved in seven inch rows. Rates of application correspond to 40 and 80 pounds of nitrogen per acre. All other factors were the same as with Trial I with the exception that the sprouts were counted for 17 days following planting.

Trial IV, involving soil from the Agronomy Farm as the germinating media, was conducted in 14 x 22 x 3 inch flats which were filled to within $\frac{1}{2}$ inch of the top. No fertilizer, crystalline urea, ammonium nitrate, pelleted Urea I, and pelleted Urea II were employed in the treatments. The treatments were applied at rates equivalent to 20, 40, and 80 pounds of nitrogen per acre. Two replications of each treatment were utilized. The application rates were based upon seven inch row spacing. Prior to planting, the fertilizer treatments were weighed on an analytical balance and the soil was thoroughly moistened. Furrows 14 inches long and one inch deep were made and the fertilizer treatments were placed in the bottom. Fifty seeds of wheat were placed directly upon top of the fertilizer in the row. After planting, the flats were watered daily and the sprouts above the soil surface were counted daily for 24 days at which time it was apparent that no more seedlings would emerge.

In Trial V the germinating media was washed fine sand. It was placed in flats 14 x 22 x 3 inches and filled to within $\frac{1}{2}$ inch of the top. This trial, using 50 wheat seeds in each 14 inch row, involved no fertilizer, crystalline urea, Urea I, Urea II, and ammonium nitrate as treatments. These treatments were applied at rates equivalent to 5, 10, 20, 40, and 80 pounds of nitrogen per acre where spacing of rows was based upon seven inch

rows. The fertilizer was made into solutions of varying concentrations in which the seeds were soaked for two hours. For the treatment involving no fertilizer, the seeds were soaked in distilled water. After soaking for two hours, the seeds were planted one inch deep in the sand and watered daily. Sprouts above the surface were counted until no additional emergence of seedlings occurred.

Trial VI involved washed fine sand as the germinating media. The sand was placed in circular pans seven inches in diameter and four inches deep. A circular furrow one inch deep and 16 inches long was made in the sand in each pan. The fertilizers were placed in the bottom of the furrow and 50 wheat seeds were placed directly upon it. No fertilizer and crystalline urea-biuret mixtures corresponding to 5, 10, and 15 per cent biuret were used at rates equivalent to 20 and 40 pounds of nitrogen per acre. Urea I also was used at rates corresponding to 20, 40, and 80 pounds of nitrogen per acre. The application rates were based upon seven inch rows. The pans were watered daily and the sprouts above the surface were counted daily until it was apparent that no further emergence of seedlings would occur.

Trial VII utilized washed fine sand as the germinating media. The germinating media was placed in flats 14 x 22 x 3 inches and filled to within one inch of the top. No treatment, crystalline urea, crystalline urea-biuret mixtures corresponding to 2.5 per cent biuret, 7.5 per cent biuret, 10 per cent biuret, and 15 per cent biuret treatments were used. The fertilizer treatments were made into solutions and the wheat seeds were soaked for two hours in the solutions before being planted in the sand. Untreated seeds were soaked in distilled water. The treatments were applied at rates equivalent to 5, 7½, 10, and 20 pounds of nitrogen per acre. The

rates were based upon seven inch rows. After planting, the flats were watered daily and the sprouts above the surface were counted daily until it was definite that no further emergence would occur.

Controlled Humidity Studies

Trial VIII involved soil from the Agronomy Farm as the germinating media and was conducted in an atmosphere of 98 per cent relative humidity. The soil was placed in circular pans seven inches in diameter and four inches deep. The soil, being air dry initially, was brought to various percentages of moisture. The percentages of moisture used were 13, 17.5, 25, and 30 per cent. These percentages corresponded to pre-determined moisture tension values. Thirteen per cent moisture corresponded to 15 atmospheres of tension (wilting point for this soil) and 25 per cent moisture corresponded to 1/3 atmosphere of tension (field capacity for this soil). No fertilizer, Urea I, Urea II, crystalline urea, ammonium nitrate, and Urea III were the fertilizer treatments used and were applied in duplicate cultures corresponding to 40 pounds of nitrogen per acre. The 40 pound per acre application rate was figured on the basis of seven inch rows. A circular furrow 16 inches long and one inch deep was made inside each pan, the fertilizer treatment was placed in the bottom of the furrow, and 50 wheat seeds were placed on top of the fertilizer. After planting, the pans were placed in an atmosphere of 98 per cent relative humidity and the sprouts above the surface were counted daily until it was definite that no further emergence of seedlings would occur.

Trial IX also was conducted under 98 per cent relative humidity conditions and soil from the Agronomy Farm was used as the germinating media.

The soil, being air dry, was brought to various moisture percentages and placed in circular pans seven inches in diameter and four inches deep. The moisture percentages used were 13, 17½, and 25 per cent which again were based upon atmospheres of tension as mentioned above. No fertilizer, crystalline urea, and ammonium nitrate fertilizer treatments were used and were applied in duplicate cultures at rates corresponding to 10 and 20 pounds of nitrogen per acre. The application rates were based upon seven inch rows. A circular furrow 16 inches long and one inch deep was made inside each pan. The fertilizer treatment was placed in the bottom of the furrow and 50 wheat seeds were placed on top of the fertilizer treatment. After planting, the pans were placed in an atmosphere of 98 per cent relative humidity and all sprouts above the surface were counted daily until it was definite that no further emergence of seedlings would occur.

RESULTS AND DISCUSSION

Greenhouse Studies

Trial I. The results of the overall trial indicated that fertilizer, when placed in contact with the seeds of corn, wheat, and milo, reduced the percentage of germination. When the fertilizer materials were applied at rates corresponding to 40 pounds per acre of the nutrients, the delay of initial germination and final maximum germination amounted to as much as eight days where the complete fertilizer treatment was employed. (Plates I, II, and III, Appendix)

The final germination percentage for the various crops was quite low for some treatments. In the case of wheat and milo, when nitrogen was

present in the fertilizer treatment, the germination percentage was reduced considerably as compared to germination which occurred where no fertilizer was used. For corn, no one fertilizer nutrient was especially more harmful than another, but when the complete fertilizer treatment was used the germination percentage was especially reduced. Combination of nitrogen and potash also gave relatively large reduction in percentage of germination. (Table 1, Appendix)

When the fertilizer treatments were applied at 20 pounds per acre application rates, the losses in final germination per cent and the delay in germination date were less than under the 40 pound per acre application rates, otherwise the same general trends as noted for the heavier rates of application did prevail. The date of initial germination and final maximum germination was delayed as much as three days where the complete fertilizer treatment was employed. (Plates IV, V, and VI, Appendix)

The final germination percentage for the crops still was quite low for some treatments even when only 20 pounds per acre of the nutrients were employed. Wheat and milo again were reduced the most when nitrogen was used in the fertilizer treatment. Corn was not reduced so much by any single fertilizer nutrient application but when two or more nutrients were combined for a treatment, especially in the case of the complete fertilizer treatment, the reduction in germination percentage usually was quite large. (Table 2, Appendix)

Trial II. This trial being the same as Trial I, with the exception of the soil, gave results that were nearly the same as for Trial I. The 40 pounds per acre application rate of fertilizer caused a delay of initial germination and final maximum dates of as much as 11 days when the complete

fertilizer treatment was used. (Plates VII, VIII, and IX, Appendix) This is a delay of three days more than was encountered in Trial I. This possibly could be attributed to the difference in soil type. The sandy soil used in Trial II undoubtedly permitted more of the fertilizer materials to remain in a mobile state.

The final germination percentages were quite low for the various crops for some of the treatments involving the use of 40 pounds per acre of fertilizer nutrients. Whenever nitrogen was present in the treatment, the germination percentages of each crop were reduced very much over the no treatment germination percentages. (Table 3, Appendix) This tendency followed very closely that which was noted for Trial I.

When the treatments were applied at 20 pounds per acre application rates, the loss in germination per cent and the delay in date of germination followed the same pattern of loss and delay of germination as when the treatments were applied at 40 pounds per acre application rates, only the losses were less. The date of initial germination and final maximum germination was delayed as much as five days with the use of the complete fertilizer treatment. (Plates X, XI, and XII, Appendix) This delay of five days caused by the 20 pound per acre application rate, was approximately one-half of the delay caused by the 40 pound per acre application rate.

The final percentage for the crops was again quite low for some treatments with 20 pounds of fertilizer application rates. Again wheat and milo were reduced the most when nitrogen was used in the fertilizer treatment. Corn was not reduced appreciably by any one fertilizer nutrient application alone but usually when any two or more nutrients were combined,

the reduction in germination percentage was considerable. (Table 4, Appendix) This reduction also follows the trend of Trial I very closely.

Trial III. This trial was performed to measure the difference in amount of damage caused by the heavier application rate per acre of fertilizer for the narrower row spacing, which actually involved less fertilizer per row. The delay in the date of initial germination and final maximum germination was as much as four days for some of the treatments when the treatments were applied at 40 pounds per acre application rates. (Plates XIII, XIV, and XV, Appendix) This delay, being somewhat less than the delay caused by the 40 pounds per acre application rate for the wider row spacing, undoubtedly was due to the smaller amount of fertilizer used in the row under these circumstances.

The final germination percentage for the crops was relatively low for the untreated soil as well as for some of the 40 pound per acre fertilizer treatments. This was undoubtedly due in part to the placement of the flats in the greenhouse. This trial was conducted in the winter and some flats had access to better heat sources than others. In the case of corn, some of the treatments may have been in small enough amounts so as to provide a stimulating effect rather than causing a detrimental effect. For wheat and milo, the reduction in germination may be attributed to the fertilizer treatments. (Table 5, Appendix)

When the fertilizer treatments for this trial were applied at 80 pounds per acre application rates, the delay in initial date of germination amounted to as much as five days for some treatments. For some treatments the date of final maximum germination amounted to as much as three days, while for other treatments it amounted to only two days. (Plates XVI, XVII,

and XVIII, Appendix) Some of this variation actually may have been due to the placement of the flats in the greenhouse.

The final germination for the crops was quite low for some of the 80 pounds per acre fertilizer treatments while for other treatments, the percentages were not reduced at all. Some of this reduction may have been due to the location in the greenhouse, but not all of it could be attributed to this factor. Milo germination, for instance, was reduced more when nitrogen was present in the treatment than when it was absent. (Table 6, Appendix)

Trial IV. This trial was conducted to determine the detrimental effect of pelleted Urea I and Urea II upon germination which neither crystalline urea nor ammonium nitrate had. When the fertilizers were applied at 20 pounds of nitrogen per acre application rates, there was no delay in the date of initial emergence. The date of final maximum germination was not delayed appreciably by either the crystalline urea or the ammonium nitrate. Urea I and Urea II both delayed final maximum germination by 10 days. Only Urea I and Urea II caused significant losses in percentage of germination. Urea I was much more damaging than was Urea II. (Plate XIX, Fig. 1, Appendix)

When the same materials were applied at 40 pounds of nitrogen per acre application rates, only Urea I and Urea II caused delays in the date of initial germination and final maximum germination. Neither ammonium nitrate nor crystalline urea caused a delay in initial germination date and final maximum germination date. Loss in final germination percentage was caused by only Urea I and Urea II. Ammonium nitrate and crystalline urea did not reduce final germination per cent when compared to the control where no

fertilizer was added. Urea I, having the highest biuret content, reduced final germination percentage to 11 per cent, a loss of 81 per cent from the control. (Plate XIX, Fig. 2, Appendix)

When the treatments were applied at 80 pounds of nitrogen per acre application rates, only Urea I and Urea II delayed the date of initial emergence, but all fertilizer treatments delayed final maximum germination when compared to the dates for the control cultures. Final germination percentage was reduced by all fertilizer treatments except by crystalline urea treatment. The loss caused by ammonium nitrate was only slight and of no practical significance, but the losses due to Urea I and Urea II were great. Urea I treatment resulted in a final germination of only 6 per cent, a loss of 86 per cent when compared to the control. (Plate XIX, Fig. 3, Appendix) It was interesting to note that ammonium nitrate, when applied at a rate of 80 pounds per acre of nitrogen did not cause as much damage as did Urea II, the one with lowest biuret content, when applied at a rate of only 20 pounds per acre of nitrogen.

Trial V. This trial was conducted to measure the effect soaking seeds in fertilizer solutions had upon germination, and to ascertain whether the biuret content of Urea I and Urea II would be more or less harmful in fertilizer solutions. When the loss in germination percentage was compared to the no treatment germination percentage, the decline in germination was rather gradual for the crystalline urea and Urea II treatments. The ammonium nitrate and Urea I treatments caused a sudden drop in germination percentage with application up to 20 pounds of nitrogen per acre and from there to the 80 pounds of nitrogen per acre application rate, the losses were gradual. (Fig. 1, Appendix) Urea I, having the highest biuret content,

reduced the germination percentage the lowest for all treatments. Soaking the seeds did not seem to delay the germination date as essentially no delay in the date of initial or final maximum germination was noted.

Trial VI. This trial was performed by using crystalline urea-biuret mixtures to determine the extent of damage caused by various contents of biuret and by various rates of application of urea containing such contents of biuret. At 20 pounds of nitrogen per acre, the losses in final germination percentage were all over 10 per cent and were as great as 64 per cent for the 15 per cent urea-biuret mixture. When the treatments were applied at 40 pounds of nitrogen per acre, the losses were significantly greater for the 10 and 15 per cent biuret mixtures and somewhat less for the 5 per cent biuret mixture. This indicated that the more concentrated the biuret, the more harmful it was on the germination of seeds. (Plate XX, Appendix) Urea I had the same effect that was observed in previous trials.

Trial VII. This trial was conducted to determine the effect of rate of application and biuret content on the germination of wheat seeds soaked in aqueous solutions of fertilizer. Crystalline urea had essentially no effect on the final germination percentage. Increasing the biuret percentage in the urea-biuret mixtures, reduced the germination percentage to such an extent that when as little as 7½ pounds of nitrogen per acre of the 15 per cent biuret mixture was applied, there was a total loss in germination. (Fig. 2, Appendix) This indicated that biuret may be very harmful to the germination of wheat.

Controlled Humidity Studies

Trial VIII. This trial was conducted to determine what modifying effects various soil moisture tensions had upon manifestation of fertilizer injury to germination of wheat seeds. When the fertilizer treatments were applied to the soil which contained only 13 per cent moisture (approximate wilting percentage), the final germination percentage was somewhat lower upon the control cultures than was true of the no treatment germination per cent for the higher moisture percentages, but the loss was not great. The final germination percentage for all other treatments was considerably lower. (Plate XXI, Fig. 1, Appendix)

For the soil containing 17½ per cent moisture, the losses due to the various fertilizer treatments were considerable, the loss being as much as 96 per cent for Urea I treatment. The crystalline urea treatment loss was somewhat less than for other fertilizer treatments, but it still was noticable. (Plate XXI, Fig. 2, Appendix)

When the fertilizer treatments were applied to the soil with 25 per cent moisture, the crystalline urea caused an insignificant loss in germination percentage. Ammonium nitrate and Urea III losses in germination percentage were somewhat greater than for either crystalline urea treatment or where no fertilizer was employed, but still not great enough to be of major consequence. Both Urea I and Urea II caused losses in germination percentages which were great enough to be highly significant. (Plate XXI, Fig. 3, Appendix)

Only one treatment, the Urea I treatment, applied to the soil with 30 per cent moisture, caused a loss in germination percentage great enough to

be of consequence. All other treatments caused no appreciable loss in germination percentage when compared to the germination upon the control cultures, except for the slight loss noted when Urea II was used. (Plate XXI, Fig. 4, Appendix) The loss in germination percentage caused by Urea I treatment again was attributed to its very high biuret content. The small loss in germination which resulted from use of Urea II also was attributed to its biuret content.

Trial IX. This trial was conducted for the purpose of determining if lower rates of fertilizer would have the same effect upon germination as were found under the conditions employed in Trial VIII.

When the fertilizer treatments were applied to the soil containing 13 per cent moisture, the 10 pound per acre crystalline urea treatment caused no loss in germination percentage. All other treatments caused losses great enough to be of significance. (Plate XXII, Fig. 1, Appendix)

For the 17½ per cent moisture level and for the 25 per cent moisture level, no fertilizer treatment caused a loss in germination percentage great enough to be of significance. (Plate XXII, Fig. 2 and 3, Appendix) By comparing the data of Trial VIII and Trial IX, it was observed that the heavier rates of application of fertilizer had tendencies to cause greater losses in germination of wheat seed.

CONCLUSIONS

In developing conclusions from this study it had to be borne in mind that all seeds were placed in direct contact with the fertilizer. Under field conditions this usually would not be the actual situation since

fertilizer attachments on planters usually place only some seeds in direct contact with the fertilizer.

Nevertheless, upon the basis of the results obtained, the following conclusions were drawn from the greenhouse studies:

1. With wheat, which frequently is drilled in seven or eight inch rows, the average application of an appropriate fertilizer, made by means of a combination grain and fertilizer drill, should reduce the germination percentage only slightly. Because of the ability of wheat plants to develop tillers, this slight reduction in germination should be of no practical importance.

2. With corn and even more especially with grain sorghums fertilizer should not be placed in the row directly in contact with the seed.

3. Urea never should be placed in the row with seed if it has or if it is suspected of containing biuret. Under the best manufacturing conditions at the present time, pelleted urea may contain as much as 2 or 3 per cent of biuret. Therefore, it appears that pelleted urea should not be applied with seeds at planting time.

4. All fertilizers reduced the germination percentage and delayed the date of emergence of wheat seedlings, but fertilizers containing biuret caused the most damage.

The following conclusions were drawn from the controlled humidity studies:

1. The percentage of soil moisture, so long as it was at the wilting percentage or higher, had little effect on the germination of seeds when no fertilizer was added and when conditions otherwise appeared to be about optimum.

2. The presence of any nitrogenous fertilizer had a marked effect on the germination of seeds, especially when the moisture supply was limited.

SUMMARY

Greenhouse studies and controlled humidity studies were conducted to determine the effect of the placement of fertilizers on the germination of wheat, milo, and corn seeds.

The greenhouse investigations were conducted using soil from the Agronomy Farm, soil from Ashland Agronomy Farm, and washed fine sand as the germinating media, the use of which varied for the various trials. The fertilizer treatments were figured on the basis of row width and varied from 20 to 80 pounds per acre application rates, always including unfertilized cultures as controls. For some trials the seeds were soaked in fertilizer solutions before being planted. For others the fertilizer was placed in the bottom of the furrow and the seeds were placed on top of the fertilizer.

The controlled humidity studies were conducted in a closed container which had water standing in the bottom under a wire screen on which the pans containing the treatments and seeds were placed. The fertilizer treatments used were figured on the basis of row width and the rate of application varied from 10 to 40 pounds of nitrogen per acre and included an unfertilized culture as a control. Soil from the Agronomy Farm, with various moisture contents, was used in these trials as the germinating media. The fertilizer treatments were placed in the bottom of furrows and the seeds were planted on top of the fertilizer in contact with it.

In the greenhouse, the trials indicated that the treatments had the same effect on the germination percentage regardless of the germinating media. Regardless of how the fertilizer was applied, in solution or dry, a similar effect on germination per cent was obtained. The trials indicated that irrespective of the germinating media or the way the treatment was applied, there generally was a delay in the date of both the initial germination and final maximum germination date when compared to the date obtained with the use of control cultures.

Commercial pelleted urea contained a substance, biuret, not contained in other commercial nitrogenous fertilizers. Biuret caused marked damage to the germination of wheat. Damage increased as percentage of biuret in urea-biuret mixtures increased. Damage also increased as rate of application of nitrogen increased.

The trials conducted under controlled humidity and various moisture contents indicated that the amount of soil moisture present had an effect on the germination of wheat seeds when fertilizer was present. This was evident because at the wilting point of the soil, the germination was not reduced greatly when no fertilizer was present, but was greatly reduced with the presence of as little as 10 pounds of nitrogen per acre.

ACKNOWLEDGMENT

The author wishes to express his sincere appreciation to his major instructor, Dr. F. W. Smith, for his interest, assistance, and helpful advice during the research work and in the preparation of this thesis.

Appreciation also is due those students and instructors who helped with their helpful criticisms and encouragement.

Acknowledgment is due Mr. Dale Friday of Nitrogen Division, Allied Chemical and Dye Corporation for his aid in obtaining biuret analyses upon all samples of urea used in these investigations.

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APPENDIX

Table 1. Effect of various fertilizer treatments on final germination of seeds (40 inch rows)
Agronomy Farm Soil

Fertilizer Treatment (Lb/A) N	P_2O_5	K_2O	% Germination of Seed of: Corn	Milo	Wheat
0	0	0	91	85	77
40	0	0	75	18	20
0	40	0	66	40	47
0	0	40	57	32	22
40	40	0	58	12	15
40	0	40	41	15	7
0	40	40	58	37	30
40	40	40	25	15	7
L.S.D.		(.05)	33.2	20	23.6
		(.01)	46.3	27.2	32.1

Table 2. Effect of various fertilizer treatments on final germination of seeds (40 inch rows)
Agronomy Farm Soil

Fertilizer Treatment (Lb/A) N	P_2O_5	K_2O	% Germination of Seed of: Corn	Milo	Wheat
0	0	0	91	85	85
20	0	0	75	47	37
0	20	0	75	67	75
0	0	20	75	62	57
20	20	0	41	47	45
20	0	20	66	60	37
0	20	20	25	52	40
20	20	20	33	27	27
L.S.D.		(.05)	23.1	17.1	4.6
		(.01)	31.4	23.2	11.8

Table 3. Effect of various fertilizer treatments on final germination of seeds (40 inch rows) Ashland Soil

Fertilizer Treatment (Lb/A) N	P_2O_5	K_2O	% Germination of Seed of: Corn	Milo	Wheat
0	0	0	91	90	90
40	0	0	58	30	25
0	40	0	80	80	65
0	0	40	75	55	42
40	40	0	33	12	12
40	0	40	41	15	20
0	40	40	66	30	15
40	40	40	25	5	10
L.S.D.		(.05)	18.1	10.6	11.8
		(.01)	24.7	14.5	16.1

Table 4. Effect of various fertilizer treatments on final germination of seeds (40 inch rows) Ashland Soil

Fertilizer Treatment (Lb/A) N	P_2O_5	K_2O	% Germination of Seed of: Corn	Milo	Wheat
0	0	0	91	90	97
20	0	0	91	42	55
0	20	0	80	75	85
0	0	20	91	80	70
20	20	0	75	52	47
20	0	20	66	40	47
0	20	20	80	47	52
20	20	20	58	27	18
L.S.D.		(.05)	19.6	9.3	17.4
		(.01)	26.7	12.7	23.6

Table 5. Effects of various fertilizer treatments on final germination of seeds (7 inch rows)
Agronomy Farm Soil

Fertilizer Treatment (Lb/A) N	P_2O_5	K_2O	% Germination of Seed of: Corn	Milo	Wheat
0	0	0	82	48	90
40	0	0	66	26	14
0	40	0	25	11	20
0	0	40	58	28	28
40	40	0	41	26	31
40	0	40	80	14	28
0	40	40	66	40	31
40	40	40	75	17	34
L.S.D.		(.05)	30.8	12.7	19.0
		(.01)	42.3	17.3	25.6

Table 6. Effects of various fertilizer treatments on final germination of seeds (7 inch rows)
Agronomy Farm Soil

Fertilizer Treatment (Lb/A) N	P_2O_5	K_2O	% Germination of Seed of: Corn	Milo	Wheat
0	0	0	82	57	77
80	0	0	25	8	11
0	80	0	80	54	68
0	0	80	75	54	77
80	80	0	66	31	62
80	0	80	41	20	54
0	80	80	80	26	62
80	80	80	8	5	48
L.S.D.		(.05)	26.5	10.4	11.4
		(.01)	36.1	14.2	15.5

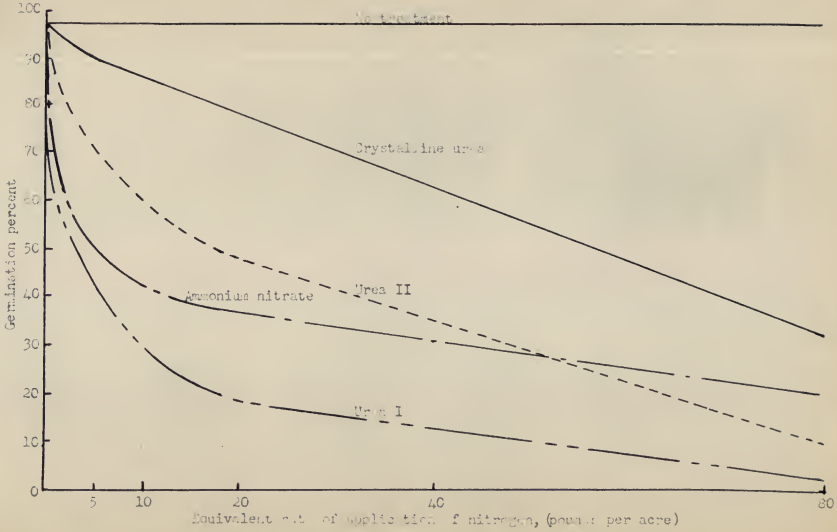


Fig. 1 Effect of soaking seeds of wheat in various fertilizer solutions of varying amounts of nitrogen.

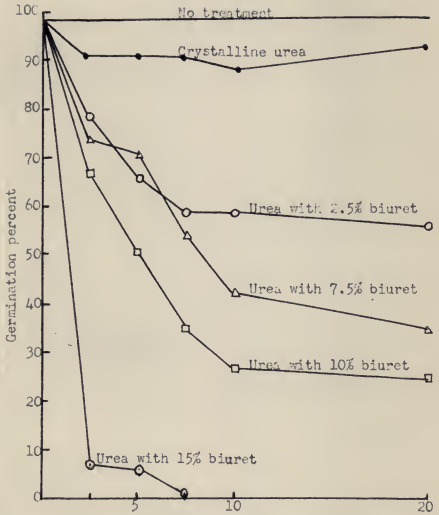


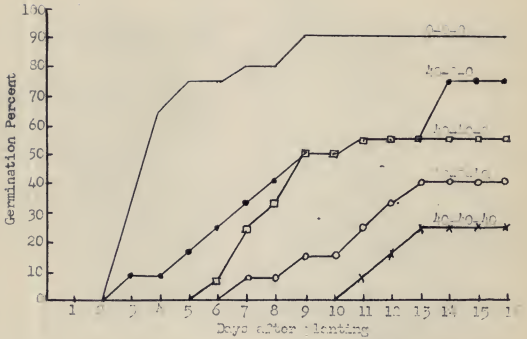
Fig. 2 Effect of rate of application and biuret content of urea on germination of wheat.

EXPLANATION OF PLATE I

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of corn seeds planted in 40 inch rows in soil from the Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of corn seeds planted in 40 inch rows in soil from the Agronomy Farm.

PLATE I



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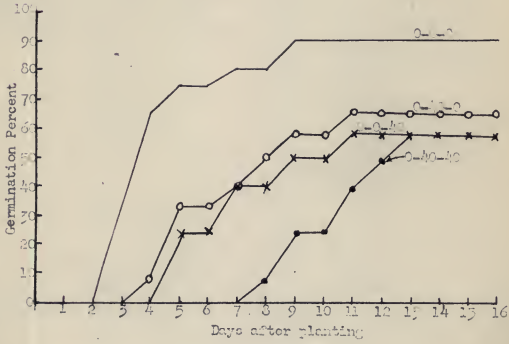


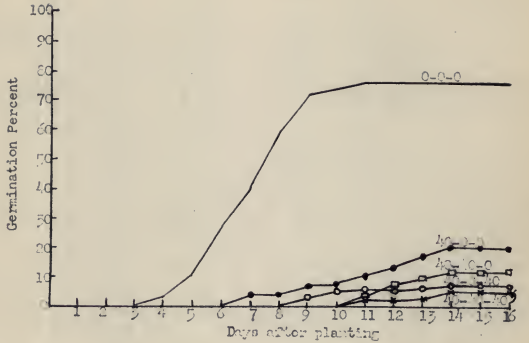
Fig. 2

EXPLANATION OF PLATE II

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of wheat seeds planted in 40 inch rows in soil from the Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of wheat seeds planted in 40 inch rows in soil from the Agronomy Farm.

PLATE II



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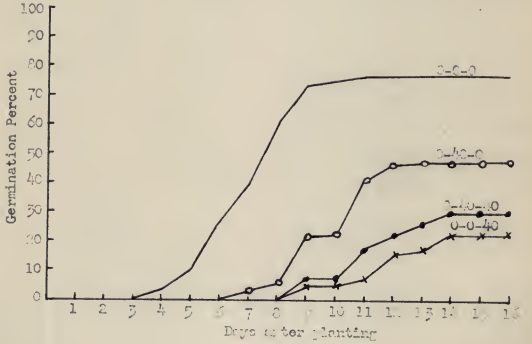


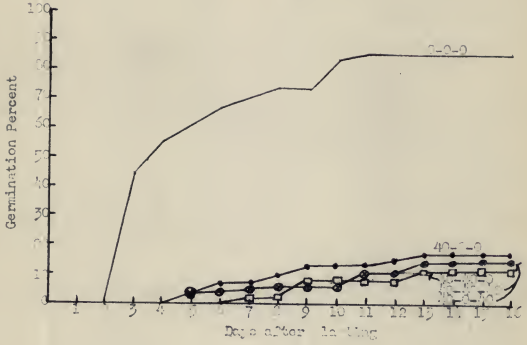
Fig. 2

EXPLANATION OF PLATE III

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of milo seeds planted in 40 inch rows in soil from the Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of milo seeds planted in 40 inch rows in soil from the Agronomy Farm.

PLATE XXX



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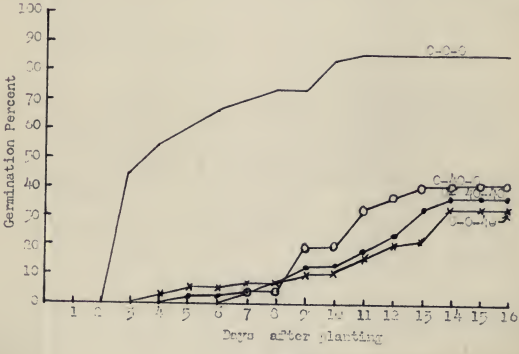


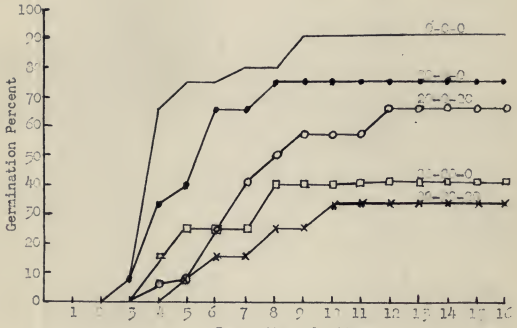
Fig. 2

EXPLANATION OF PLATE IV

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 20 pounds per acre application rates on the delay of germination of corn seeds planted in 40 inch rows in soil from the Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 20 pounds per acre application rates on the delay of germination of corn seeds planted in 40 inch rows in soil from the Agronomy Farm.

PLATE IV



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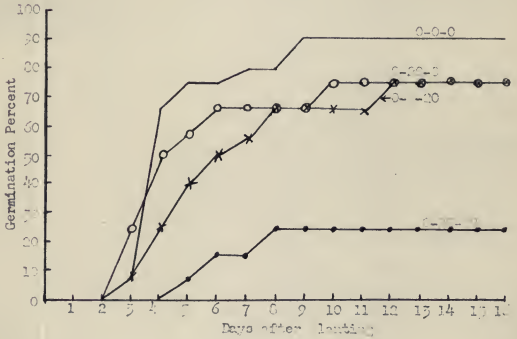


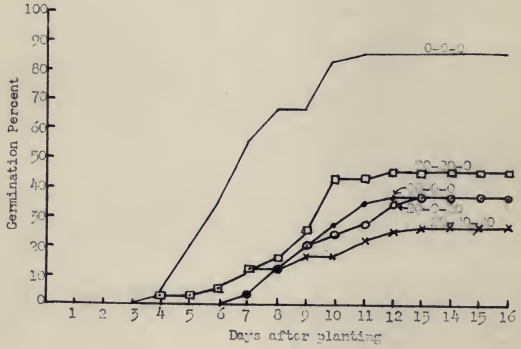
Fig. 2

EXPLANATION OF PLATE V

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 20 pounds per acre application rates on the delay of germination of wheat seeds planted in 40 inch rows in soil from the Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 20 pounds per acre application rates on the delay of germination of wheat seeds planted in 40 inch rows in soil from the Agronomy Farm.

PLATE V



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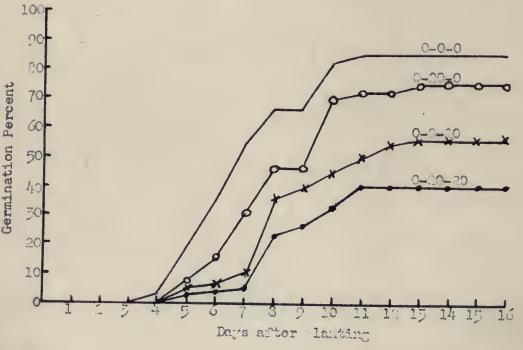


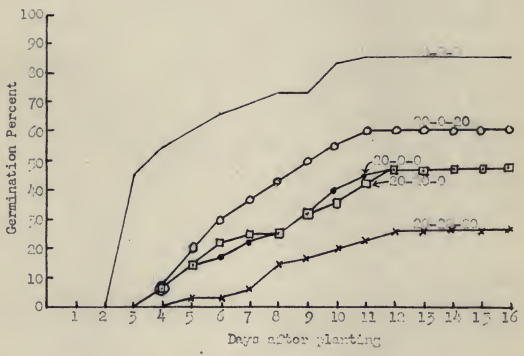
Fig. 2

EXPLANATION OF PLATE VI

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 20 pounds per acre application rates on the delay of germination of milo seeds planted in 40 inch rows in soil from the Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 20 pounds per acre application rates on the delay of germination of milo seeds planted in 40 inch rows in soil from the Agronomy Farm.

PLATE VI



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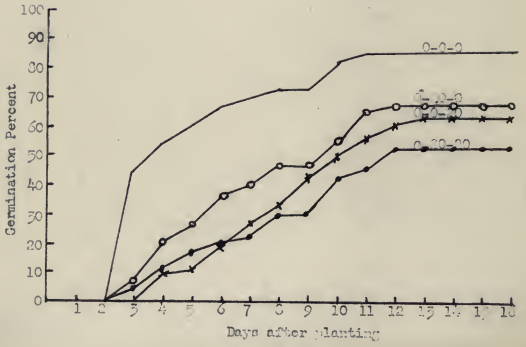


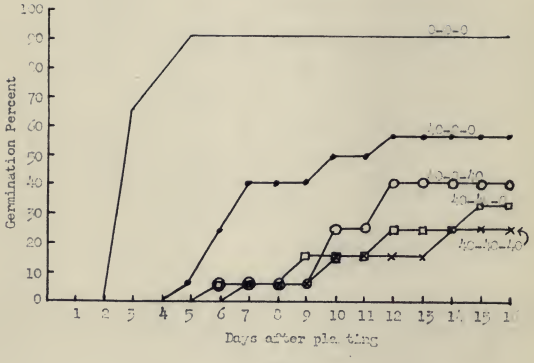
Fig. 2

EXPLANATION OF PLATE VII

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of corn seeds planted in 40 inch rows in soil from the Ashland Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of corn seeds planted in 40 inch rows in soil from the Ashland Agronomy Farm.

PLATE VII



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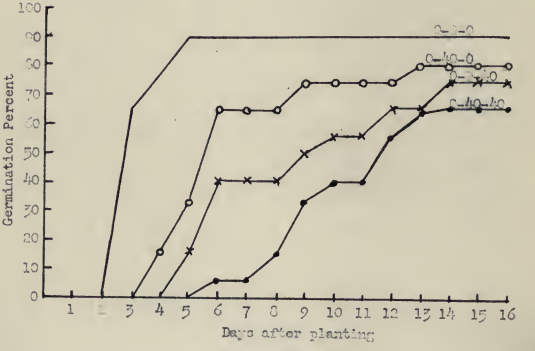


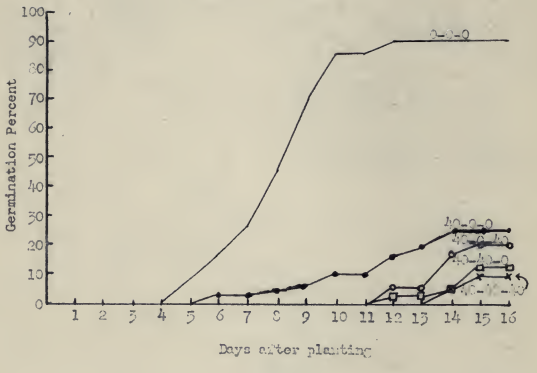
Fig. 2

EXPLANATION OF PLATE VIII

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of wheat seeds planted in 40 inch rows in soil from the Ashland Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of wheat seeds planted in 40 inch rows in soil from the Ashland Agronomy Farm.

PLATE VIII



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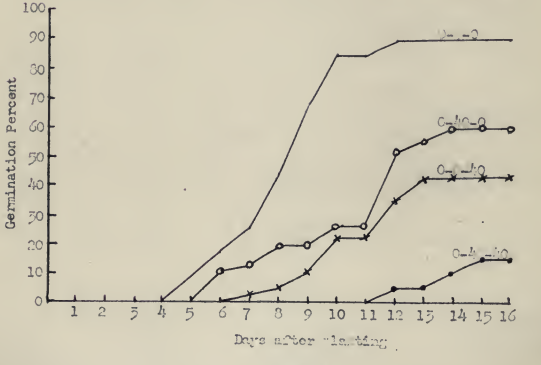


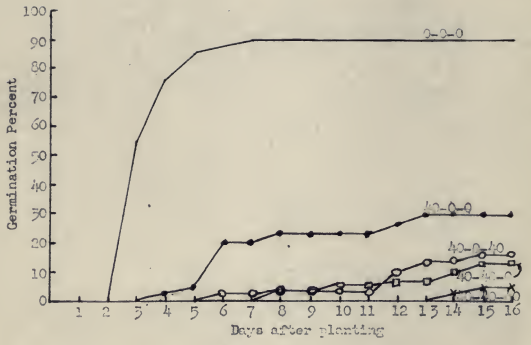
Fig. 2

EXPLANATION OF PLATE IX

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of milo seeds planted in 40 inch rows in soil from the Ashland Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of milo seeds planted in 40 inch rows in soil from the Ashland Agronomy Farm.

PLATE IX



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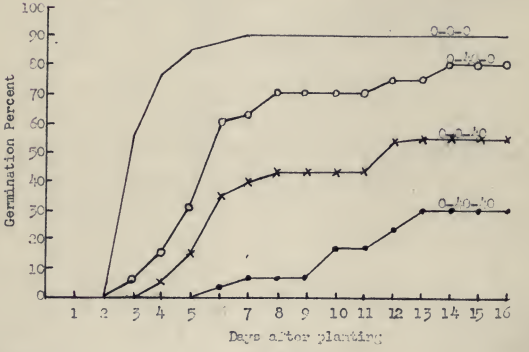


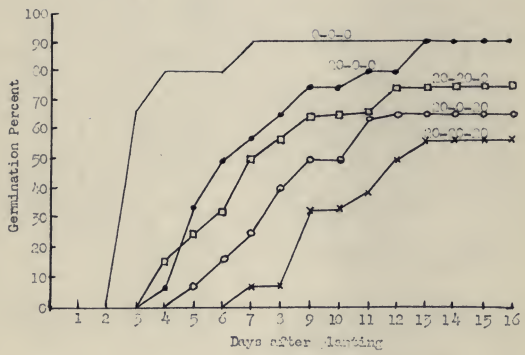
Fig. 2

EXPLANATION OF PLATE X

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 20 pounds per acre application rates on the delay of germination of corn seeds planted in 40 inch rows in soil from the Ashland Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 20 pounds per acre application rates on the delay of germination of corn seeds planted in 40 inch rows in soil from the Ashland Agronomy Farm.

PLATE X



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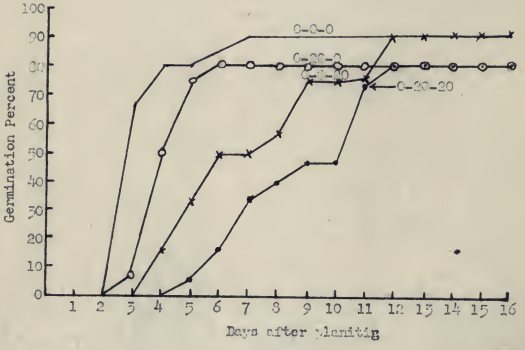


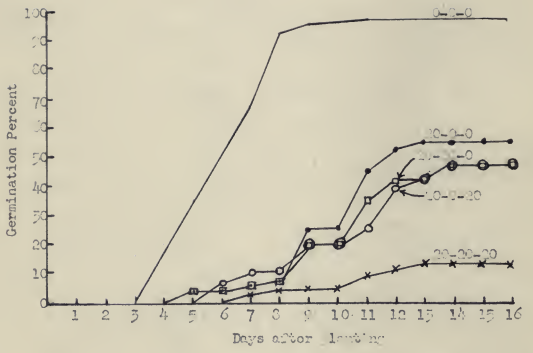
Fig. 2

EXPLANATION OF PLATE XI

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 20 pounds per acre application rates on the delay of germination of wheat seeds planted in 40 inch rows in soil from the Ashland Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 20 pounds per acre application rates on the delay of germination of wheat seeds planted in 40 inch rows in soil from the Ashland Agronomy Farm.

PLATE XI



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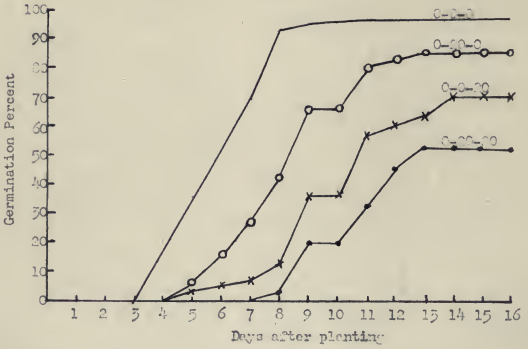


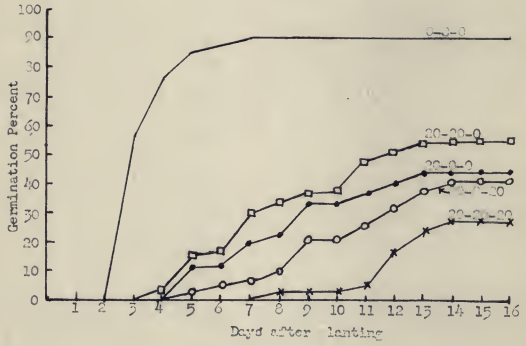
Fig. 2

EXPLANATION OF PLATE XII

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 20 pounds per acre application rates on the delay of germination of milo seeds planted in 40 inch rows in soil from the Ashland Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 20 pounds per acre application rates on the delay of germination of milo seeds planted in 40 inch rows in soil from the Ashland Agronomy Farm.

PLATE XII



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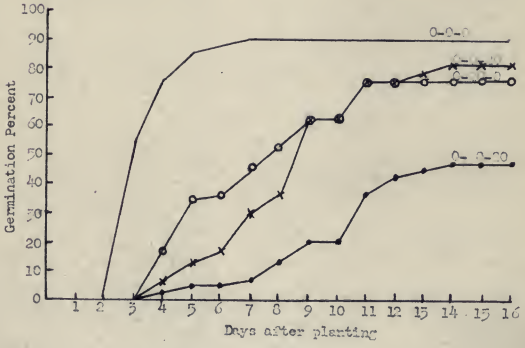


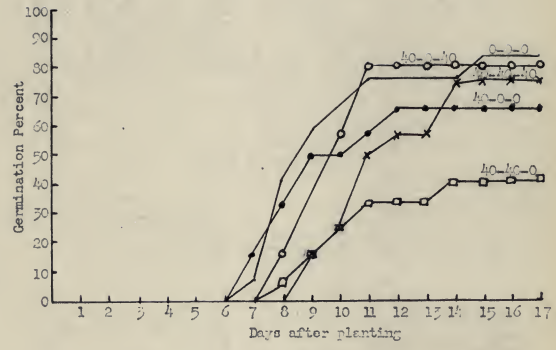
Fig. 2

EXPLANATION OF PLATE XIII

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of corn seeds planted in 7 inch rows in soil from the Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of corn seeds planted in 7 inch rows in soil from the Agronomy Farm.

PLATE XIII



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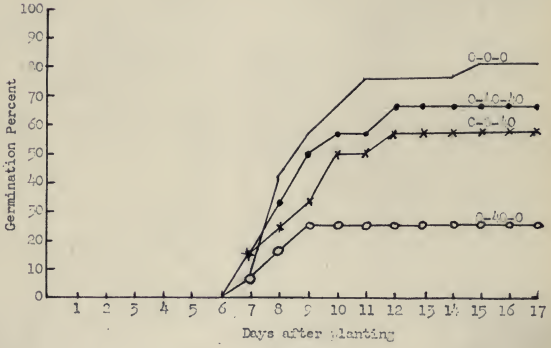


Fig. 2

EXPLANATION OF PLATE XIV

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of wheat seeds planted in 7 inch rows in soil from the Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of wheat seeds planted in 7 inch rows in soil from the Agronomy Farm.

PLATE XIV

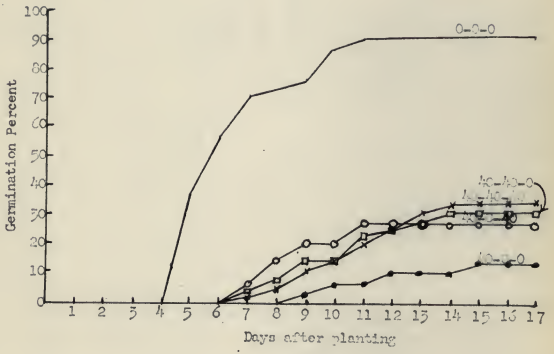


Fig. 1

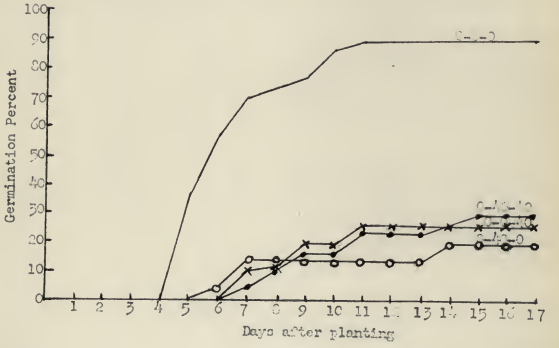


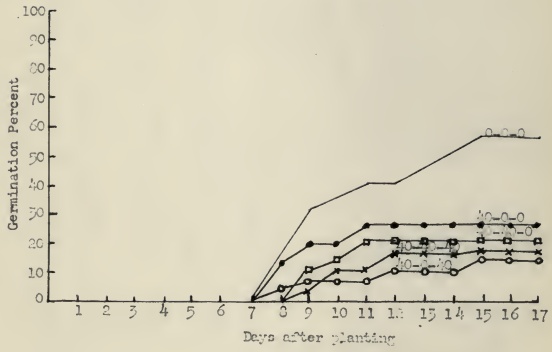
Fig. 2

EXPLANATION OF PLATE XV

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of milo seeds planted in 7 inch rows in soil from the Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 40 pounds per acre application rates on the delay of germination of milo seeds planted in 7 inch rows in soil from the Agronomy Farm.

PLATE XV



Fi . 1

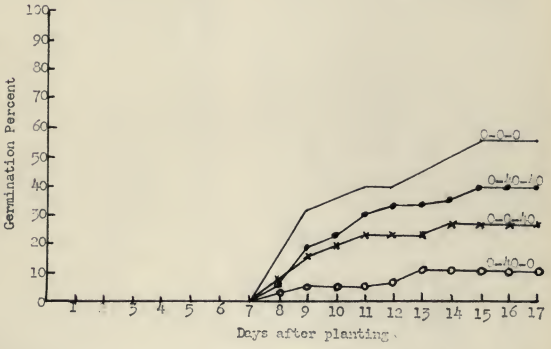


Fig. 2

EXPLANATION OF PLATE XVI

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 80 pounds per acre application rates on the delay of germination of corn seeds planted in 7 inch rows in soil from the Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 80 pounds per acre application rates on the delay of germination of corn seeds planted in 7 inch rows in soil from the Agronomy Farm.

PLATE XVI

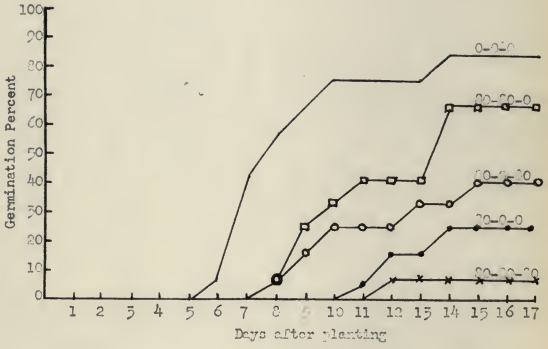


Fig. 1

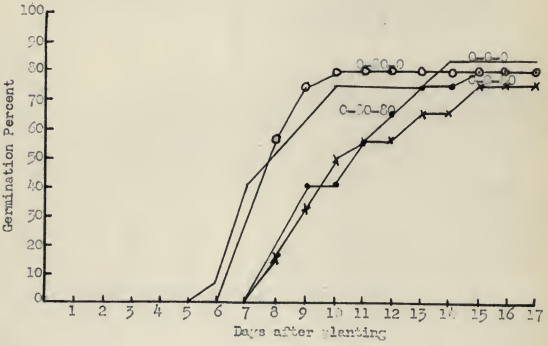


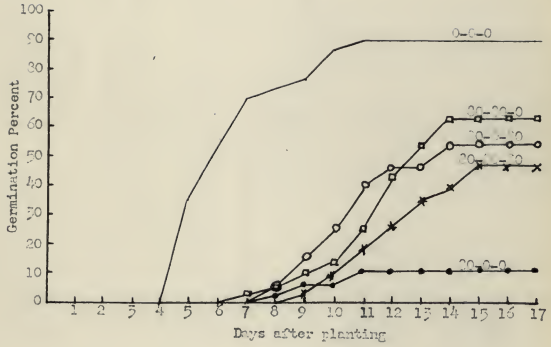
Fig. 2

EXPLANATION OF PLATE XVII

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 80 pounds per acre application rates on the delay of germination of wheat seeds planted in 7 inch rows in soil from the Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 80 pounds per acre application rates on the delay of germination of wheat seeds planted in 7 inch rows in soil from the Agronomy Farm.

PLATE XVII



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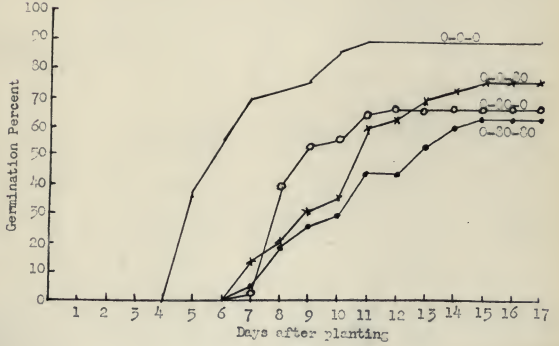


Fig. 2

EXPLANATION OF PLATE XVIII

Fig. 1 The effect of no treatment and fertilizer treatments containing nitrogen applied at 80 pounds per acre application rates on the delay of germination of milo seeds planted in 7 inch rows in soil from the Agronomy Farm.

Fig. 2 The effect of no treatment and fertilizer treatments not containing nitrogen applied at 80 pounds per acre application rates on the delay of germination of milo seeds planted in 7 inch rows in soil from the Agronomy Farm.

PLATE XVIII

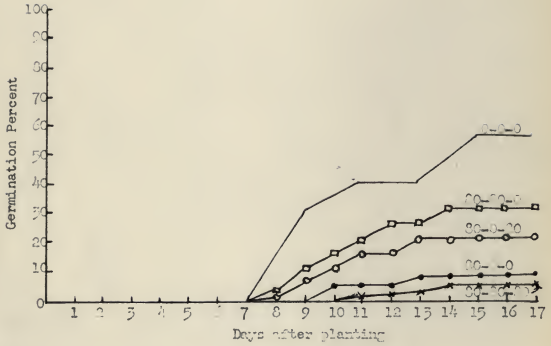


Fig. 1

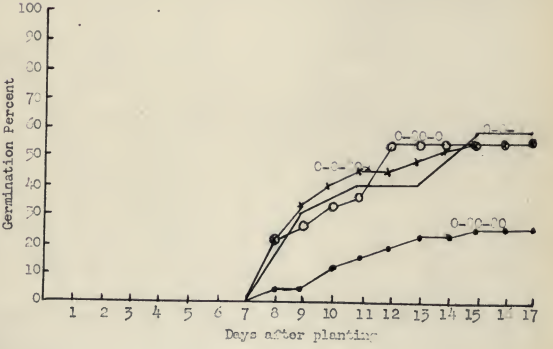


Fig. 2

EXPLANATION OF PLATE XIX

Fig. 1 The effect of various nitrogen fertilizers applied at 20 pounds of nitrogen per acre application rates on germination of wheat seeds planted in 7 inch rows in soil from the Agronomy Farm.

Fig. 2 The effect of various nitrogen fertilizers applied at 40 pounds of nitrogen per acre application rates on germination of wheat seeds planted in 7 inch rows in soil from the Agronomy Farm.

Fig. 3 The effect of various nitrogen fertilizers applied at 80 pounds of nitrogen per acre application rates on germination of wheat seeds planted in 7 inch rows in soil from the Agronomy Farm.

Least significant differences between treatments:

.05 = 12.3%
.01 = 17.3%

PLATE XIX

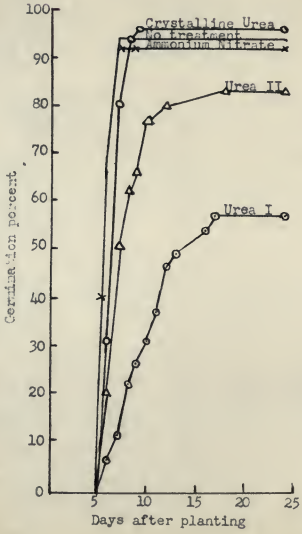


Fig. 1

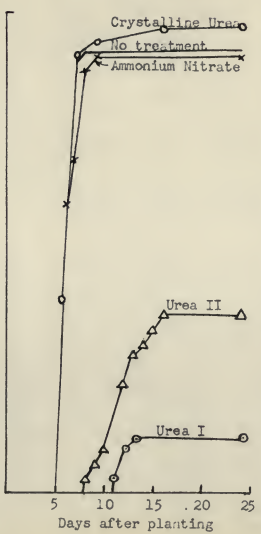


Fig. 2

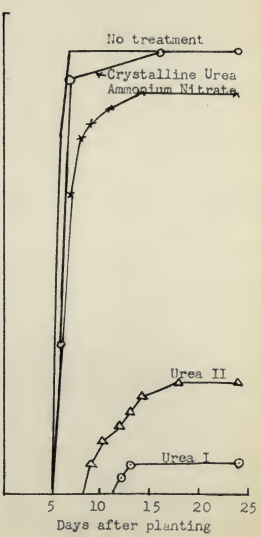


Fig. 3

EXPLANATION OF PLATE XX

Fig. 1 The effect of various treatments of urea-biuret mixtures of known percentages of biuret and Urea I applied at 20 pounds of nitrogen per acre on the germination of wheat seeds planted in 7 inch rows in washed fine sand.

Fig. 2 The effect of various treatments of urea-biuret mixtures of known percentages of biuret and Urea I applied at 40 pounds of nitrogen per acre on the germination of wheat seeds planted in 7 inch rows in washed fine sand.

Fig. 3 The effect of the Urea I treatment applied at 80 pounds of nitrogen per acre on the germination of wheat seeds planted in 7 inch rows in washed fine sand.

Treatments are as follows:
1. Urea with 5% biuret
2. Urea with 10% biuret
3. Urea with 15% biuret
4. Urea I

Least significant differences between treatments involving known percentages of biuret and control cultures only:

.05 = 11.52%
.01 = 17.44%

PLATE XX

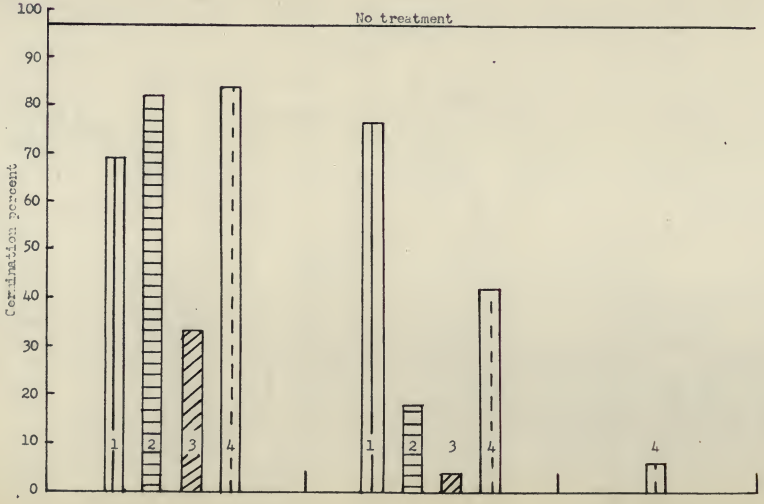


Fig. 1 Fig. 2 Fig. 3

EXPLANATION OF PLATE XXI

Fig. 1 The effect of various sources of nitrogen fertilizer applied at the equivalent of 40 pounds per acre application rates on the germination of wheat seeds planted in soil from the Agronomy Farm with 13 per cent moisture.

Fig. 2 The effect of various sources of nitrogen fertilizer applied at the equivalent of 40 pounds per acre application rates on the germination of wheat seeds planted in soil from the Agronomy Farm with 17.5 per cent moisture.

Fig. 3 The effect of various sources of nitrogen fertilizer applied at the equivalent of 40 pounds per acre application rates on the germination of wheat seeds planted in soil from the Agronomy Farm with 25 per cent moisture.

Fig. 4 The effect of various sources of nitrogen fertilizer applied at the equivalent of 40 pounds per acre application rates on the germination of wheat seeds planted in soil from the Agronomy Farm with 30 per cent moisture.

Treatments are as follows:

1. No treatment
2. Ammonium nitrate
3. Urea I
4. Urea II
5. Crystalline urea
6. Urea III

Least significant differences between treatments:

.05 = 0.82%
.01 = 1.12%

PLATE XXI

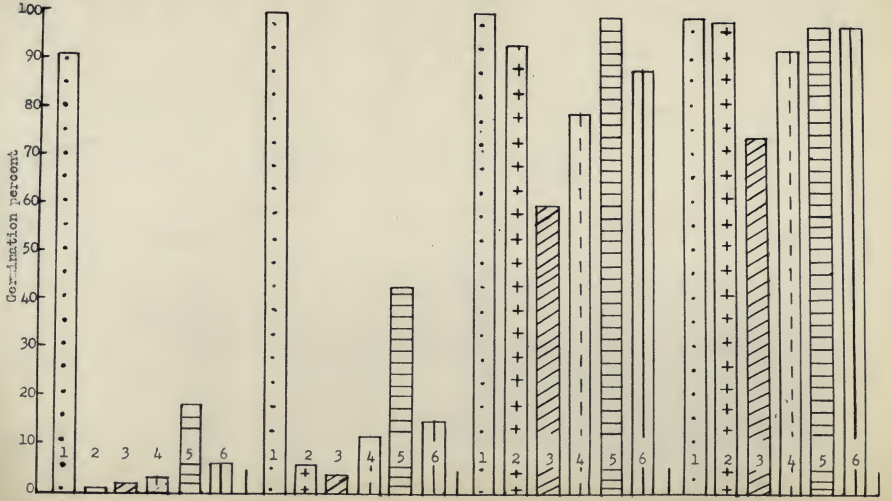


Fig. 1 Fig. 2 Fig. 3 Fig. 4

EXPLANATION OF PLATE XXII

Fig. 1 The effect of various fertilizer treatments on the germination of wheat seeds planted in soil from the Agronomy Farm with 13 per cent moisture.

Fig. 2 The effect of various fertilizer treatments on the germination of wheat seeds planted in soil from the Agronomy Farm with 17.5 per cent moisture.

Fig. 3 The effect of various fertilizer treatments on the germination of wheat seeds planted in soil from the Agronomy Farm with 25 per cent moisture.

Treatments are as follows:

1. No treatment
2. Ammonium nitrate, 20 pounds per acre
3. Ammonium nitrate, 10 pounds per acre
4. Crystalline urea, 20 pounds per acre
5. Crystalline urea, 10 pounds per acre

Least significant differences between treatments:

.05 = 3.0%
.01 = 4.3%

PLATE XXII

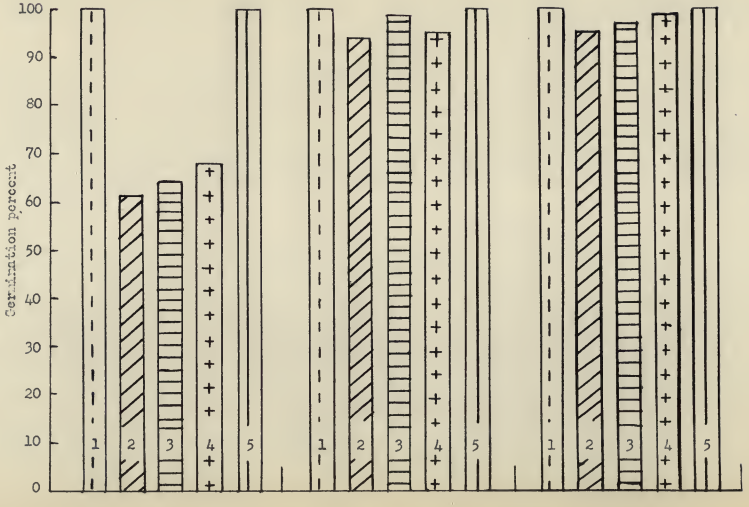


Fig. 1 Fig. 2 Fig. 3

EXPLANATION OF PLATE XXIII

Fig. 1 The effect of various fertilizer treatments applied at 40 pounds per acre application rates on the germination of wheat, corn, and milo planted in 40 inch rows in soil from the Agronomy Farm.

Fig. 2 The effect of various fertilizer treatments applied at 40 pounds per acre application rates on the germination of wheat, corn, and milo planted in 40 inch rows in soil from the Agronomy Farm.

Crops are as follows, left to right:
Corn
Milo
Wheat

PLATE XXIII

Fig. 1

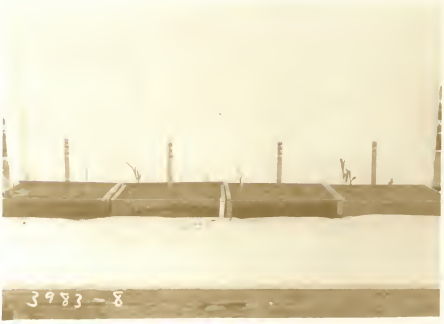


Fig. 2

EXPLANATION OF PLATE XXIV

Fig. 1 The effect of various fertilizer treatments applied at 20 pounds per acre application rates on the germination of wheat, corn, and milo planted in 40 inch rows in soil from the Agronomy Farm.

Fig. 2 The effect of various fertilizer treatments applied at 20 pounds per acre application rates on the germination of wheat, corn, and milo planted in soil from the Agronomy Farm.

Crops are as follows, left to right:
Corn
Milo
Wheat

PLATE XXIV

Fig. 1

Fig. 2

EXPLANATION OF PLATE XXV

Fig. 1 The effect of various fertilizer treatments applied at 40 pounds per acre application rates on the germination of wheat, corn, and milo planted in 40 inch rows in soil from the Ashland Agronomy Farm.

Fig. 2 The effect of various fertilizer treatments applied at 40 pounds per acre application rates on the germination of wheat, corn, and milo planted in 40 inch rows in soil from the Ashland Agronomy Farm.

Crops are as follows, left to right:
Wheat
Milo
Corn

PLATE XXV

Fig. 1

Fig. 2

EXPLANATION OF PLATE XXVI

Fig. 1 The effect of various fertilizer treatments applied at 20 pounds per acre application rates on the germination of wheat, corn, and milo planted in 40 inch rows in soil from the Ashland Agronomy Farm.

Fig. 2 The effect of various fertilizer treatments applied at 20 pounds per acre application rates on the germination of wheat, corn, and milo planted in 40 inch rows in soil from the Ashland Agronomy Farm.

Crops are as follows, left to right:
Wheat
Milo
Corn

PLATE XXVI

Fig. 1

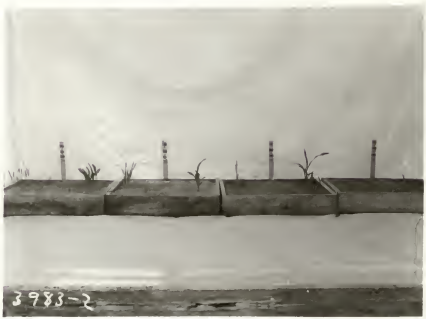


Fig. 2

EXPLANATION OF PLATE XXVII

Fig. 1 The effect of various nitrogenous fertilizer treatments applied at 20 pounds of nitrogen per acre on the germination of wheat planted in 7 inch rows in soil from the Agronomy Farm.

Fig. 2 The effect of various nitrogenous fertilizer treatments applied at 40 pounds of nitrogen per acre on the germination of wheat planted in 7 inch rows in soil from the Agronomy Farm.

PLATE XXVII

Fig. 1

Fig. 2

EXPLANATION OF PLATE XXVIII

The effect of various nitrogenous fertilizer treatments applied at 80 pounds of nitrogen per acre on the germination of wheat planted in 7 inch rows in soil from the Agronomy Farm.

PLATE XXVIII

EXPLANATION OF PLATE XXIX

Fig. 1 The effect of various percentages of biuret in urea-biuret mixtures applied at 20 pounds of nitrogen per acre on the germination of wheat planted in 7 inch rows in washed fine sand.

Fig. 2 The effect of various percentages of biuret in urea-biuret mixtures applied at 40 pounds of nitrogen per acre on the germination of wheat planted in 7 inch rows in washed fine sand.

PLATE XXIX

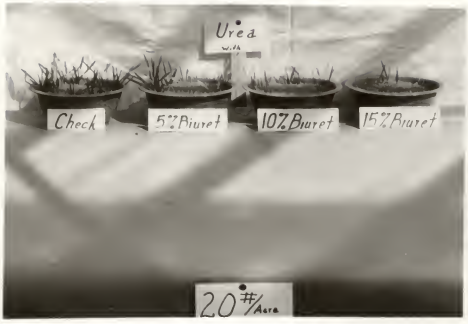


Fig. 1

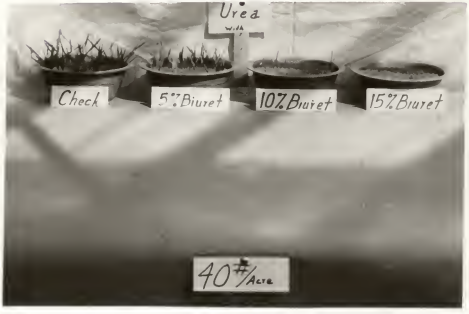
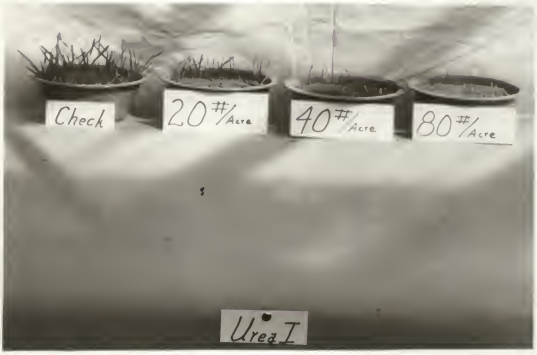


Fig. 2

EXPLANATION OF PLATE XXX

The effect of Urea I applied at 20, 40, and 80 pounds of nitrogen per acre on the germination of wheat seeds planted in 7 inch rows in washed fine sand.

PLATE XXX



SEED GERMINATION AS AFFECTED BY FERTILIZER APPLICATIONS

by

Darryl Eugene Smika

B. S., Kansas State College
of Agriculture and Applied Science, 1956

AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1956

In general agricultural soils are decreasing in fertility with continual cultivation. In recent years, commercial fertilizers have been used to counteract this loss in fertility. New manufacturing processes have produced types of fertilizer which have new and different properties. In many cases the method of application of these new fertilizers cannot be the same as was employed with older types of fertilizer because the new ones may be more highly concentrated in nutrient content.

In order to determine the effect of direct application fertilizers with the seeds of crops, studies were conducted in the greenhouse in which crop seeds were placed in direct contact with various fertilizer materials. Interference of such placement of fertilizer upon seed germination was measured. Soil from the Agronomy Farm, soil from Ashland Agronomy Farm, and washed fine sand were used as germination media. Fertilizer treatment application rates were calculated upon the basis of linear row length and varied from 20 to 80 pounds per acre. Fertilizers used were ammonium nitrate, triple superphosphate, muriate of potash, two sources of commercial prilled urea, crystalline urea-biuret mixtures, and pure crystalline urea. Wheat, corn, and milo seeds were utilized in the investigations. In the bottom of furrows one inch deep the known number of seeds was placed directly upon a band of fertilizer. Flats planted to the various seeds were watered daily and seedlings emerging above the surface were counted daily until it was evident that no more would emerge. Effects of such placement were compared with control flats where no fertilizer was used. Special trials were conducted with soil from the Agronomy Farm with various known moisture percentages in a controlled relative humidity of 98 per cent. The fertilizer applications again were calculated on linear row

length and varied from 10 to 40 pounds of nutrient per acre. The fertilizers used were ammonium nitrate, three sources of commercial prilled urea, and pure crystalline urea. Furrows one inch deep were made with the fertilizer treatments being placed in the bottom and a known number of wheat seeds planted on top of the fertilizer. The planted containers were placed in an atmosphere of 98 per cent relative humidity and the seedlings appearing above the surface were counted daily until it was evident that no more would emerge.

In general the germination percentage of all crops was reduced some by each fertilizer treatment irrespective of the germination media. The losses were the greatest for the heavy application rates and least for the lighter rates depending on the row width. In general nitrogenous fertilizers and muriate of potash caused more germination damage than did superphosphate. One sample of urea in particular caused considerable damage, this effect was attributed to its high biuret content. Other commercial prilled ureas caused germination damage in proportion to biuret content. The damaging effect of biuret also was demonstrated in mixtures of urea and biuret. Degree of damage depended both upon relative biuret content and relative rate of application per linear unit of row.

The trials conducted with various moisture percentages and at 98 per cent relative humidity indicated that fertilizer application reduced germination percentage especially at low soil moisture tension. Near the wilting point even low rate of fertilizer application caused extensive damage. Also the germination percentage was lowered with the heavier fertilizer application rates at each soil moisture tension.

Corn and milo crops are especially subject to germination injury because of being planted in relatively wide-apart rows. With such row spacing the fertilizer is much more concentrated than with small grains. Results of this study indicate that urea or mixed fertilizer made from urea containing biuret never should be placed in direct contact with seed.

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